MITSUBISHI ELECTRIC

700 series

INVERTER
FR-E700-SC(-EC)(-NA)/NF/NC

Safety stop function instruction manual

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Compliance with the EU Machinery Directive – Functional Safety

WARNING

Any misuse of safety function could lead to personal injury or death, property damage, or economic loss.
To ensure that the system complies fully with requirement of safety, make a system-level risk assessment.
Mitsubishi Electric Co. cannot assume responsibility for any system to comply with safety directive.

CAUTION

The information of this manual is merely a guide for proper installation.
Mitsubishi Electric Co. cannot assume responsibility for the compliance or the noncompliance to any code, national, local or otherwise for the proper installation of this equipment.
A hazard of personal injury and/or equipment damage exists if codes are ignored during installation.

WARNING

To avoid an electric shock hazard, verify that the voltage on the bus capacitors has discharged before performing any work on the drive. Measure the DC bus voltage at the P(+) and N(-) terminals or test points (refer to your drive's *User Manual* for locations and discharging time). The voltage must be zero.

WARNING

The safety stop function do not isolate electrically between drive and motor. To avoid an electric shock hazard, disconnect/isolate power to the drive and verify to ensure that the voltage is zero before performing any work on the motor (refer to your drive's *User Manual* for discharging time).

CAUTION

FR-E700-SC/NF/NC which has the following SERIAL number are compatible with ISO13849.

<FR-E700-SC/NF/NC series of Japanese specifications>
FR-E700-SC: Fxxxxx or later
FR-E700-NF: Exxxxx or later
FR-E700-NC: Three-phase 200V class 0.1K to 0.75K: Cxxxxx or later
Three-phase 200V class 1.5K to 3.7K/11K/15K: Bxxxxx or later
Three-phase 200V class 5.5K/7.5K: Dxxxxx or later
(Three-phase 400V class and single-phase 200V class are all compatible.)

<FR-E700-SC series of NA, EC specifications>
Compatible for all models.

Check the SERIAL number indicated on the inverter rating plate or package.

Rating plate example

□	○	○	○○○○○○
Symbol	Year	Month	Control number

SERIAL (Serial No.)

The SERIAL consists of 1 version symbol, 2 numeric characters or 1 numeric character and 1 alphabet letter indicating year and month, and 6 numeric characters indicating control number.
Last digit of the production year is indicated as the Year, and the Month is indicated by 1 to 9, X (October), Y (November), and Z (December).

1. General description

Features

Mitsubishi FR-E700-SC/NF/NC safety stop function prevents a drive from supplying rotational energy to motors. Dual safety channels 'S1' and 'S2' cut off the gate-drive power for IGBT to turn off.

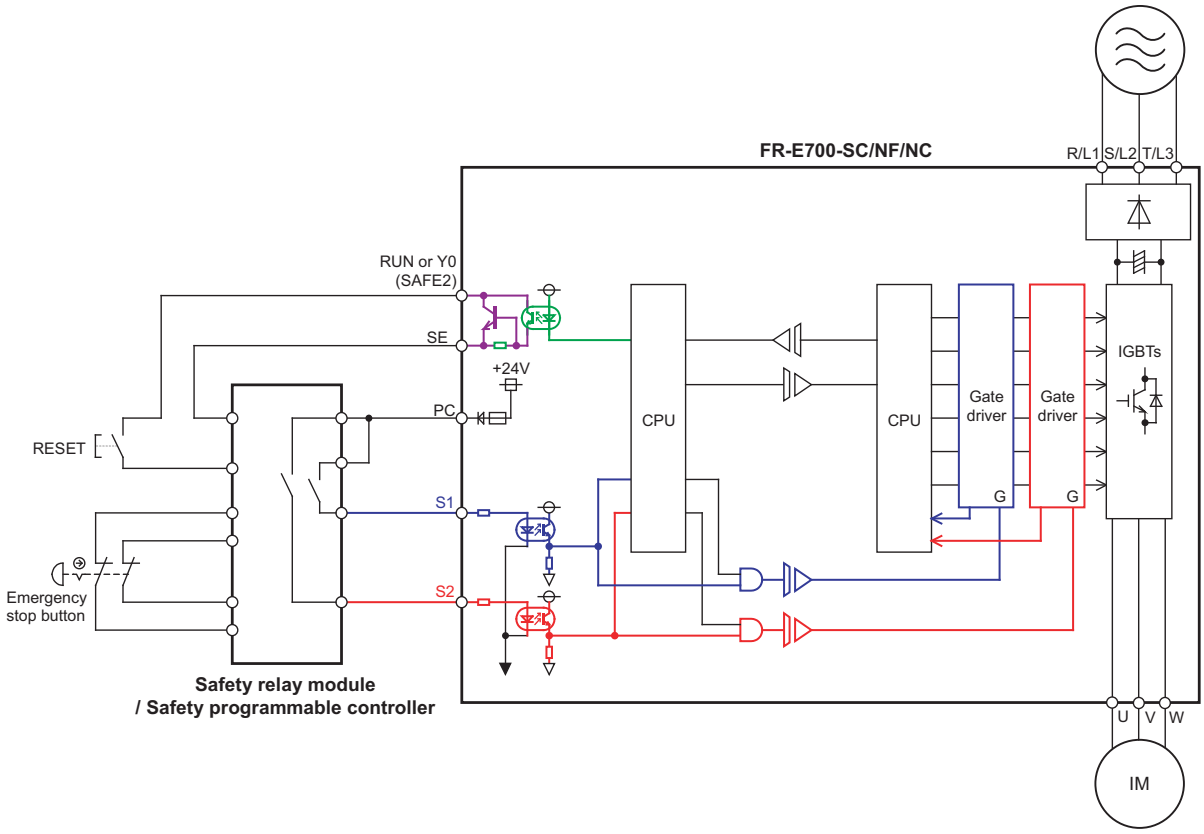


Fig.1 FR-E700-SC/NF/NC safety stop function diagram

WARNING
The safety stop function doesn't isolate electrically between drive and motor. To avoid an electric shock hazard, disconnect power to the drive and verify that the voltage is zero before performing any work on the motor (refer to your drive's *User Manual* for discharging time).

Standards

Mitsubishi FR-E700-SC/NF/NC safety stop function meets the following directives and categories.

ISO13849-1:2008 Category 3/PLd
IEC62061:2005 / IEC61800-5-2:2007 / IEC61508 SIL2
IEC60204-1:2006 / IEC61800-5-2:2007 Stop category 0

WARNING
The misuse of safety function leads to personal injury or death, property damage, or economic loss. To ensure that the system complies fully with requirement of safety, make a system-level risk assessment. Mitsubishi Electric Co. cannot assume responsibility for any system to comply with safety directive.

2. Installation and wiring

CAUTION
The following information is merely a guide for proper installation. Mitsubishi Electric Co. cannot assume responsibility for the compliance or the noncompliance to any code, national, local or otherwise for the proper installation of this equipment. A hazard of personal injury and/or equipment damage exists if codes are ignored during installation.

CAUTION
Ensure the safety relay unit and the FR-E700-SC/NF/NC unit is mounted closely in enclosure meeting IP54 and all interconnection wiring is short and protected against open and short circuit faults. Refer ISO/IEC13849-2.

Installation

Mitsubishi FR-E700-SC/NF/NC safety stop function should be used under following condition and environment.

Table.1 The condition and environment for using safety stop function

Item		Condition
Temperature range	Operation	-10ºC to +50ºC (non-freezing)
	Storage	-20ºC to +65ºC
Ambient humidity		90%RH maximum (non-condensing)
Vibration		5.9m/s^2 or less
Altitude		maximum 1000m above sea level
Atmosphere		Indoors (without corrosive gas, flammable gas, oil mist, dust and dirt etc.)
Over voltage category		II or less
Pollution degree		II or less
Mounting		wall mounting / vertical orientation

CAUTION
In order to meet safety stop, an approved safety relay unit to ISO13849-1/EN954-1 safety category 3 or better shall be used in conjunction with FR-E700-SC/NF/NC as shown in example. In addition, all other components with in the safety stop loop shall be ‘safety approved’ types.

WARNING
To avoid an electric shock hazard, insert the magnetic contactor (MC) between power source and drive. Open the contact of MC and keep away from drive for discharging time (refer to your drive’s *User Manual* for information) before performing any work on the drive. And verify that the voltage on the bus capacitors has discharged before Measure the DC bus voltage at the P(+) and N(-) terminals or test points (refer to your drive’s *User Manual* for locations). The voltage must be zero.

CAUTION
To avoid systematic faults, a test even for faulty demands of the safety function has to be performed in order to check the correct function of the monitor signal. This test shall be carried out at system installation, any software changes, parameterization changes, and/or at least once per year. Refer to ‘4. Test and checking failure’.

Wiring
The safety related terminals are described in Table.2 and Table.3

Table.2 The safety related terminals

Terminal Symbol	Description	Rating [*2]
S1	For input of safety stop channel1. S1-PC is Open: In safety stop mode. Short: Non safety stop mode.	Input resistance: 4.7kΩ Input Current : 4 to 6 mA (In case of shorted to PC) Input Voltage : 21 to 26.5 V
S2	For input of safety stop channel2. S2-PC is Open: In safety stop mode. Short: Non safety stop mode.	
PC	Common terminal for S1,S2 signals. *PC is connected to 24V power source through diode and fuse.	Output Voltage 22V to 26.5V Output Current : 100mA max.
RUN or Y0 (SAFE2)	As output for failure detection and alarm. RUN terminal type is 'Open collector output'. RUN or Y0-SE is OFF(Open): Detect failure or Alarm. ON(Close): No failure detected. **Attention:** To use RUN terminal or Y0 terminal for monitor output of failure detection, **The parameter No.190 should be set "81" (Safety monitor 2).** **Note:** This terminal can be used for alarm or to prevent restart only, no other safety function.	Load: 24VDC/0.1A max. Voltage drop: 3.4V max. (In case of 'ON' state)
SE	Common terminal for RUN terminal and Y0 terminal.	
A, C [*1] (SAFE2)	As output for failure detection. A,C terminal type is 'Relay output'. A-C is OFF(Open): Detect failure or Alarm. ON(Close): No failure detected. **Attention:** To use A,C terminal for monitor output of failure detection, **The parameter No.192 should be set "81" (Safety monitor 2).** **Note:** This terminal can be used for alarm or to prevent restart only, no other safety function.	Load: 30VDC/0.3A max.

[*1] The relay terminal is equipped for FR-E700-SC.
[*2] Specifications for conforming safety standards.

Table.3 Truth table of Safety related signals

Input power	S1-PC	S2-PC	Internal safety circuit fault *1	RUN, Y0-SE or A-C (SAFE2) *2*3	Drive state
OFF	-	-	-	OFF(Open)	Drive shutoff (Safe state)
ON	Short	Short	No failure	ON(Close)	Drive enable
			Detected	OFF(Open)	Drive shutoff (Safe state)
	Open	Open	No failure	ON(Close)	Drive shutoff (Safe state)
			Detected	OFF(Open)	Drive shutoff (Safe state)
	Short	Open	N/A	OFF(Open)	Drive shutoff (Safe state)
	Open	Short	N/A	OFF(Open)	Drive shutoff (Safe state)

"N/A" denotes a condition where circuit fault does not apply.

*1 At an internal safety circuit fault, one of E.SAF, E.6, E.7, and E.CPU is displayed on the operation panel. SA is displayed on the operation panel while S1 and S2 signals are both open and the safety function operates (without internal safety circuit fault).

*2 To use RUN or Y0 terminal for monitor output of failure detection, the parameter No.190 should be set "81" (Safety monitor 2).

*3 To use A,C terminal for monitor output of failure detection, the parameter No.192 should be set "81" (Safety monitor 2).

Wire and ferrule specification

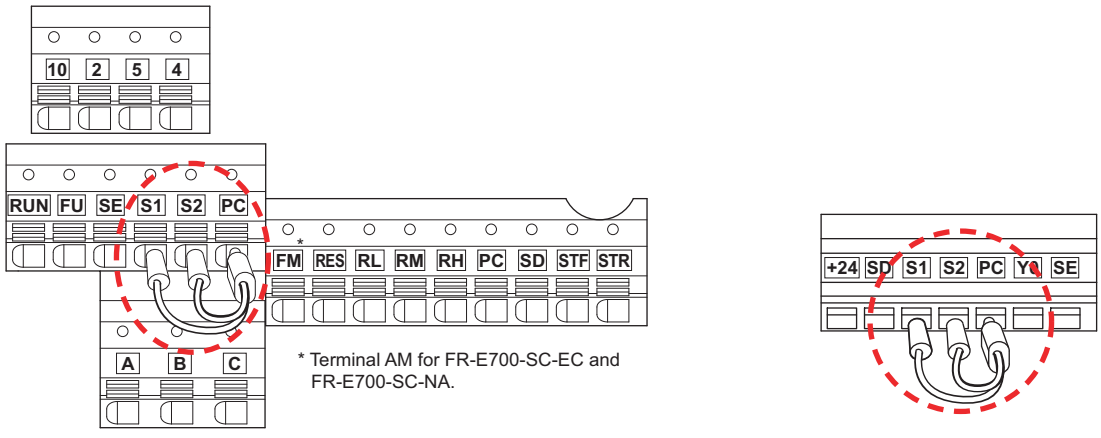
Table.4 wire and ferrule specification

Wire size (mm^2)	Ferrule with insulation collar *	Crimping tool *
0.3 / 0.5	AI 0,5-10WH	CRIMPFOX 6/6T-F
0.75	AI 0,75-10GY	
1	AI 1-10RD	
1.25 / 1.5	AI1,5-10BK	
0.75 (combined 2 wire)	AI TWIN 2 X 0,75-10GY	

*Ferrules and tools are distributed by Phoenix Contact.

Jumper cable

The jumper cable between S1,S2 and PC terminal has been installed in the factory as shown in Fig.2.



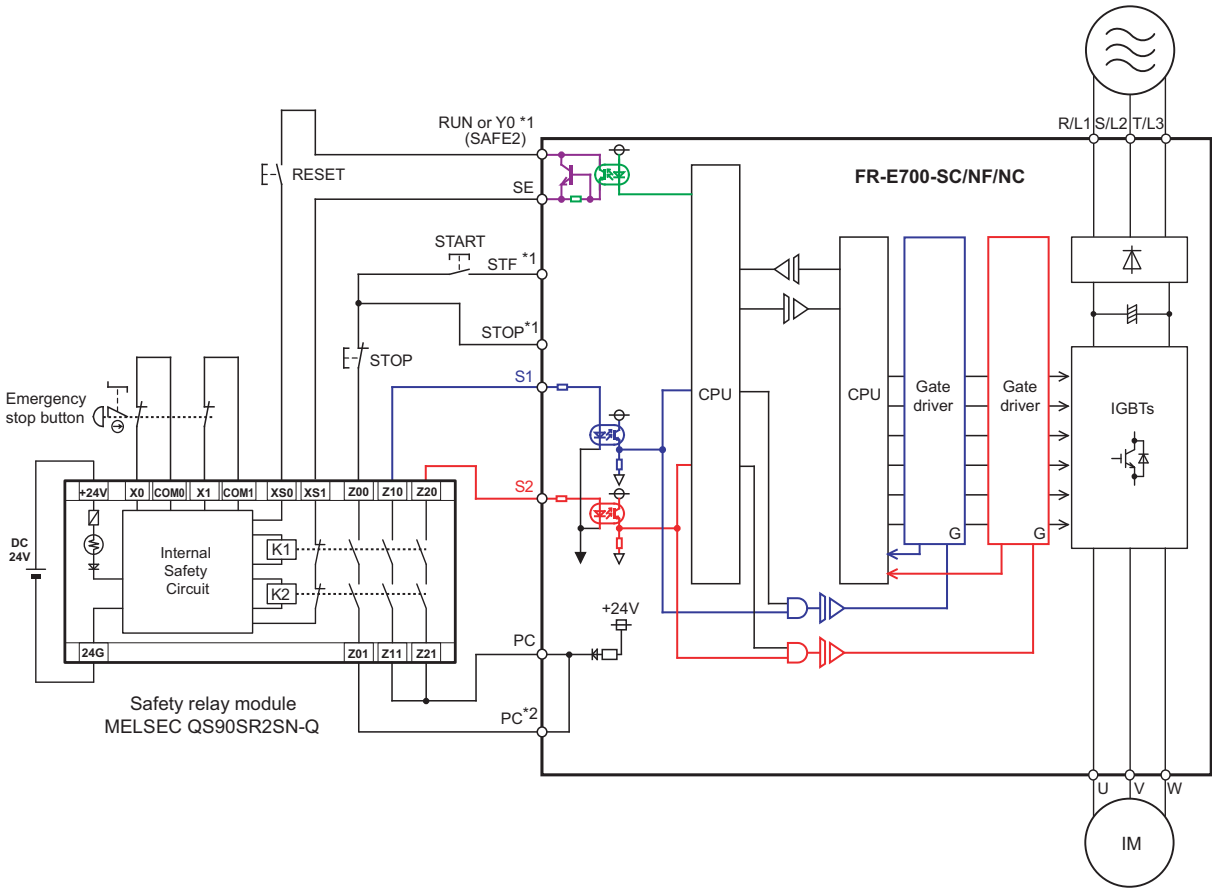
Terminal block of FR-E700-SC

Terminal block of FR-E700-NF/NC

Fig.2. Short wire

Before connecting safety input wire to S1,S2 and PC terminal, remove this jumper cable.

3. Example of safety system configuration



*1 STF and STOP terminals are equipped for FR-E700-SC. Y0 terminal is equipped instead of RUN terminal for FR-E700-NF/NC.
*2 If the control logic is SINK logic, the common terminal is terminal SD.

Fig.3 Safety system example

For safety stop, configure the wiring as shown in Fig.3 above.

NOTE

- **To use RUN or Y0 terminal for monitor output of failure detection, the parameter No.190 must be set to "81". This setting makes the RUN or Y0-SE output to open in case of failure.**
- **After the power-ON, to reset the safety stop mode, press the RESET switch, and also press the START switch, then start the motor rotation.**
- **In the above configuration, after reset of emergency stop button, drive will be in safe-state until RESET switch is pressed.**
- **Do not connect the FR-D700 sink-logic safety terminal model together with the FR-E700-SC/NF/NC series. If connected together, the safety stop function does not work properly.**

CAUTION
To prevent restart in case of recovering from input power loss of drive, 3-wired connection for START/STOP control is recommended. In case of 2-wire connection and using latching type switch to short between STF and SD/PC for starting, ensure the compliance with safety requirement for the restarting when the drive recover from input power loss. (FR-E700-SC only)

4. Test and checking failure

CAUTION
To avoid systematic faults, a test even for faulty demands of the safety function has to be performed in order to check the correct function of the monitor signal. This test shall be carried out at system installation, any software changes, parameterization changes, and/or at least once per year.

I/O status and failure

FR-E700-SC/NF/NC safety related I/O status obeys the following truth table.

Table.5 Truth table of Safety related signals

Input power	S1-PC	S2-PC	Internal safety circuit fault *1	RUN, Y0-SE or A-C (SAFE2) *2*3	Drive state
OFF	-	-	-	OFF(Open)	Drive shutoff (Safe state)
ON	Short	Short	No failure	ON(Close)	Drive enable
			Detected	OFF(Open)	Drive shutoff (Safe state)
	Open	Open	No failure	ON(Close)	Drive shutoff (Safe state)
			Detected	OFF(Open)	Drive shutoff (Safe state)
	Short	Open	N/A	OFF(Open)	Drive shutoff (Safe state)
	Open	Short	N/A	OFF(Open)	Drive shutoff (Safe state)

"N/A" denotes a condition where circuit fault does not apply.

*1 At an internal safety circuit fault, one of E.SAF, E.6, E.7, and E.CPU is displayed on the operation panel. SA is displayed on the operation panel while S1 and S2 signals are both open and the safety function operates (without internal safety circuit fault).

*2 To use RUN or Y0 terminal for monitor output of failure detection, the parameter No.190 should be set "81" (Safety monitor 2).

*3 To use A,C terminal for monitor output of failure detection, the parameter No.192 should be set "81" (Safety monitor 2).

In case of diagnostic or functionality test, check the I/O state whether it is same or not as Table.5.

Diagnostic

If the failure detected, FR-E700-SC/NF/NC output alarm signal and indicate ‘E.SAF’ at the display.
In case of FR-E700-SC/NF/NC output the alarm, please take following action.

(1) Check the S1-PC and S2-PC input signal logic is the same. If these are different logic, collect the input signal and reset the FR-E700-SC/NF/NC.
(2) Disconnect the wire from S1, S2, PC terminal, then reset or power-off and on, If the ‘SA’ letter is flashed up at display, there is failure in system except FR-E700-SC/NF/NC. But, still ‘E.SAF’ is displayed and alarm output, there is malfunction on FR-E700-SC/NF/NC.

Self diagnostic test

FR-E700-SC/NF/NC does the self-diagnostic test on the power-ON.
If FR-E700-SC/NF/NC output alarm (SA, E.SAF) at power-up, please take the action described in ‘Diagnostic’ at above.

Test procedure for functionality

As depicted ‘ATTENTION’ in above, the test for the functionality is important.
Please do the test following procedure.

(1) Please make each state of S1-PC and S2-PC depicted at Table.5.
(2) If there is any different state from Table.5, FR-E700-SC/NF/NC has some malfunction.
(3) If there is no different state from Table.5, check the systematic performance, such as, press the Emergency switch, press the start/restart button at the failure detected (RUN or Y0-SE opened), and so on.
(4) Finally clear the error record of the FR-E700-SC/NF/NC (see the user manual how to clear the error record).

5. Safety parameters of FR-E700-SC/NF/NC

The safety parameters of FR-E700-SC/NF/NC are depicted as follows.

Table.6 Safety parameters of FR-E700-SC/NF/NC

Parameter	Value
PFD_{AVG}	$4.02x10^{-4}$
PFH_D	$4.59x10^{-9}$
PL	d
$MTTF_D$	504 years
DC_{AVG}	60%

REVISIONS

Print Date	Manual Number	Revision
Mar. 2010	BCN-A211508-004-A	First edition
Aug. 2010	BCN-A211508-004-B	Modification Specification of SAFE signal
Jan. 2011	BCN-A211508-004-C	Correction of the applicable FR-E700-SC SERIAL number
Dec. 2011	BCN-A211508-004-D	Addition FR-E700-NC Series

HEADQUARTERS

MITSUBISHI ELECTRIC EUROPE EUROPE B.V.
German Branch
Gothaer Straße 8
D-40880 Ratingen
Phone: +49 (0) 21 02 / 486-0
Hotline: +49 2102 1805 000-765 /-766
Fax: +49 (0) 21 02 / 4 86-1 12 0
e mail: megfa-mail@meg.mee.com
www.mitsubishi-automation.com

MITSUBISHI ELECTRIC FRANCE FRANCE
25, Boulevard des Bouvets
F-92741 Nanterre Cedex
Phone: +33 1 55 68 55 68
Fax: +33 1 49 01 07 25
e mail: factory.automation@fra.mee.com

MITSUBISHI ELECTRIC ITALY EUROPE B.V.
Italian Branch
C.D. Colleoni-P. Perseo Ing. 2
Via Paracelso 12
I-20041 Agrate Brianza (MI)
Phone: +39 (0) 39 / 60 53 1
Fax: +39 (0) 39 / 60 53 312
e mail: factory.automation@it.mee.com

MITSUBISHI ELECTRIC SPAIN EUROPE B.V.
Pol. Ind. Can Magi-C.
Calle Joan Buscallá, 2-4 AC 420
E-08190 Sant Cugat del Vallés
Phone: +34 (9) 3 / 565 31 31
Fax: +34 (9) 3 / 589 29 48

MITSUBISHI ELECTRIC UK EUROPE B.V.
UK Branch
Travellers Lane
Hatfield, Hertfordshire, AL10 8 XB
Phone: +44 (0) 1707 / 27 61 00
Fax: +44 (0) 1707 / 27 86 95

MITSUBISHI ELECTRIC JAPAN CORPORATION
Tokyo Bldg.
2-7-3 Marunouchi Chiyoda-Ku
Tokyo 100-8310
Phone: +81 (0) 3 / 32 18 31 76
Fax: +81 (0) 3 / 32 18 24 22

MITSUBISHI ELECTRIC USA AUTOMATION
500 Corporate Woods Parkway
Vernon Hills, Illinois 60061
Phone: +1 (0) 847 / 478 21 00
Fax: +1 (0) 847 / 478 03 27

EUROPEAN REPRESENTATIVES

GEVA AUSTRIA
Wiener Straße 89
A-2500 Baden
Phone: +43 (0) 2252 / 85 55 20
Fax: +43 (0) 2252 / 488 60
e mail: office@geva.co.at

Getronics b.v. BELGIUM
Control Systems
Pontbeeklaan 43
B-1731 Asse-Zellik
Phone: +32 (0) 2 / 4 67 17 51
Fax: +32 (0) 2 / 4 67 17 45
e mail: infoautomation@getronics.com

TELECON CO. BULGARIA
4, A. Ljapchev Blvd.
BG-1756 Sofia
Phone: +359 92 / 97 44 05 8
Fax: +359 92 / 97 44 06 1
e mail: ——

AutoCont CZECHIA
Control Systems s.r.o.
Nemocnicni 12
CZ-70200 Ostrava 2
Phone: +420 (0) 69 / 615 21 11
Fax: +420 (0) 69 / 615 21 12
e mail: ——

louis poulsen DENMARK
industri & automation
Geminivej 32
DK-2670 Greve
Phone: +45 (0) 43 / 95 95 95
Fax: +45 (0) 43 / 95 95 91
e mail: lpia@lpmail.com

UTU Elektrotehnika AS ESTONIA
Pärnu mnt. 160i
EE-10621 Tallinn
Phone: +372 6 / 51 72 80
Fax: +372 6 / 51 72 88
e mail: utu@utu.ee

URHO TUOMINEN OY FINLAND
Hevoshaankatu 3
FIN-28600 Pori
Phone: +358 (0) 2 / 55 08 00
Fax: +358 (0) 2 / 55 088 41
e mail: ——

UTECO A.B.E.E. GREECE
5, Mavrogenous Str.
GR-18542 Piraeus
Phone: +30 (0) 1 / 42 10 050
Fax: +30 (0) 1 / 42 12 033
e mail: uteco@uteco.gr

EUROPEAN REPRESENTATIVES

MITSUBISHI ELECTRIC IRELAND EUROPE B.V.-Irish Branch
Westgate Business Park
Ballymount
IRL-Dublin 24
Phone: +353 (0) 1 / 419 88 00
Fax: +353 (0) 1 / 419 88 90
e mail: sales.info@meuk.mee.com

ALFATRADE LTD. MALTA
99 Paola Hill
Paola PLA 08
Phone: +356 / 697816
Fax: +356 / 697817
e mail: paul.licari@alfatrx.com

Getronics bv NETHERLANDS
Control Systems
Donauweg 10
NL-1043 AJ-Amsterdam
Phone: +31 (0) 20 / 586 15 92
Fax: +31 (0) 20 / 586 19 27
e mail: infoautomation@getronics.com

Beijer Electronics AS NORWAY
Teglverksveien 1
N-3002 Drammen
Phone: +47 (0) 32 / 24 30 00
Fax: +47 (0) 32 / 84 85 77
e mail: ——

MPL Technology SP.Z.o.o POLAND
ul.Wroclawska 53
PL-30-011 Kraków
Phone: +48 (0) 12 / 632 28 85
Fax: +48 (0) 12 / 632 47 82
e mail: krakow@mpl.com.pl

Sirius Trading&Services srl ROMANIA
Bd. Ghica nr. 112, Bl. 41
RO-72335 Bucaresti 2
Phone: +40 (0) 1 / 210 55 11
Fax: +40 (0) 1 / 210 55 11
e mail: sirius_t_s@fx.ro

ACP AUTOCOMP a.s. SLOVAKIA
Chalupkova 7
SK-81109 Bratislava
Phone: +421 (0) 7 592 22 54
Fax: +421 (0) 7 592 22 48
e mail: ——

INEA d.o.o. SLOVENIA
Ljubljanska 80
SI-1230 Domžale
Phone: +386 (0) 17 21 80 00
Fax: +386 (0) 17 24 16 72
e mail: inea@inea.si

EUROPEAN REPRESENTATIVES

Beijer Electronics AB SWEDEN
Box 426
S-20123 Malmö
Phone: +46 (0) 40 / 35 86 00
Fax: +46 (0) 40 / 93 23 02
e mail: ——

ECONOTEC AG SWITZERLAND
Postfach 282
CH-8309 Nürensdorf
Phone: +41 (0) 1 / 838 48 11
Fax: +41 (0) 1 / 838 48 12
e mail: ——

GTS TURKEY
Darülaceze Cad. No. 43A KAT: 2
TR-80270 Okmeydani-Istanbul
Phone: +90 (0) 212 / 320 1640
Fax: +90 (0) 212 / 320 1649
e mail: ——

EURASIAN REPRESENTATIVES

MITSUBISHI ELECTRIC RUSSIA EUROPE B.V.
12/1 Goncharnaya St, suite 3C
RUS-109240 Moskow
Phone: +7 (0) 95 / 915-8624/02
Fax: +7 (0) 95 / 915-8603
e mail: ——

STC Drive Technique RUSSIA
Poslannikov per., 9, str. 1
RUS-107005 Moskow
Phone: +7 (0) 95 / 786 21 00
Fax: +7 (0) 95 / 786 21 01
e mail: ——

JV-CSC Automation UKRAINE
15, M. Raskovoyi St., Floor 10,
Office 1010
U-02002 Kiev
Phone: +380 (4) 4 / 238 83 16
Fax: +380 (4) 4 / 238 83 17
e-Mail: mkl@csc-a.kiev.ua

MIDDLE EAST REPRESENTATIVE

SHERF Motion Techn. LTD ISRAEL
Rehov Hamerkava 19
IL-58851 Holon
Phone: +972 (0) 3 / 559 54 62
Fax: +972 (0) 3 / 556 01 82
e mail: ——

MITSUBISHI ELECTRIC CORPORATION

HEAD OFFICE: TOKYO BUILDING 2-7-3, MARUNOUCHI, CHIYODA-KU, TOKYO 100-8310, JAPAN

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